

# Smoking Susceptibility and Tobacco Media Engagement Among Youth Never Smokers

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## abstract

**BACKGROUND:** Susceptibility to future smoking among youth never smokers has not changed in the past 20 years, although experimental cigarette smoking has decreased. We assessed how smoking susceptibility and tobacco industry-related marketing influenced smoking initiation.

**METHODS:** Four waves (2013–2018) of the Population Assessment of Tobacco and Health Study data were analyzed among youth aged 12 to 17 years at wave 1 who completed wave 4. Susceptibility was assessed by 4 items (openness to curiosity, try soon, try in the next year, and if your best friend offered) and categorized into 4 levels (0 = definitely no to all; 1 = yes to 1; 2 = yes to 2; and 3 + 4 = yes to 3 or 4 susceptibility items). Multivariable logistic regression evaluated how susceptibility levels, electronic cigarette use, and tobacco-related media activity predicted future experimental ( $\geq 1$  puff), current (past 30 days), or established ( $\geq 100$  cigarettes) smoking.

**RESULTS:** Among 8899 never smokers at wave 1, 16.4% became experimental smokers, 7.6% current smokers, and 1.8% established smokers at wave 4. Black and Latino/a youth were less likely to experiment. Youth who endorsed 3 or 4 susceptibility items at wave 1 were more likely to be experimental (adjusted odds ratio [aOR] = 6.0; confidence interval [CI] = 4.8–7.4), current (aOR = 4.2; CI = 3.2–5.4), or established (aOR = 4.4; CI = 2.4–7.9) smokers at wave 4. Exposure to tobacco marketing, using tobacco-related apps, seeing social media content posted about tobacco, and ever use of electronic cigarettes also predicted experimental smoking.

**CONCLUSIONS:** Smoking susceptibility and exposure to tobacco industry-related marketing were predictive of cigarette smoking. Clinicians should consider screening adolescents for smoking susceptibility and tobacco-related media exposure.



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**WHAT'S KNOWN ON THIS SUBJECT:** The proportion of youth who are never smokers has increased, but susceptibility to future cigarette use has not changed in 20 years. Less is known about how smoking susceptibility and recent industry-related activity influence smoking initiation among youth.

**WHAT THIS STUDY ADDS:** After adjustment for demographics and tobacco-related media activity exposures, level of smoking susceptibility at baseline predicted experimental, current, and established smoking among 12- to 17-year-old youth 4 years later. Black and Latino/a youth were less likely to experiment with cigarettes.

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Experimentation with cigarettes occurs during adolescence, leading to the establishment of cigarette use by age 18 for 90% of adult smokers.<sup>1-3</sup> Although smoking initiation is rare in adults after age 26, age of initiation occurs more frequently in young adulthood, especially among racial and/or ethnic minorities.<sup>1,3-5</sup> However, the emergence of electronic cigarette use as the most widely used tobacco products among middle school and high school students presents a new pathway for nicotine use.<sup>6,7</sup> Several studies indicate that youth whose first tobacco product was an electronic cigarette were more likely to initiate combustible cigarettes or report past 30-day cigarette use.<sup>8-10</sup> Despite a substantial reduction in youth experimentation with cigarette smoking, the proportion of never smokers who remain susceptible to future cigarette use has not changed over the past 20 years.<sup>11,12</sup>

The original 3-item measure of susceptibility was developed by using cross-sectional data from the 1992 California Tobacco Survey to assess the relationship between susceptibility and future cigarette smoking and has been used across other susceptibility studies since.<sup>13</sup> Among youth who had never used a cigarette, nonsusceptible youth were identified as those who would “definitely not” (1) try a cigarette soon, (2) smoke a cigarette in the next year, and (3) smoke a cigarette offered from a best friend.<sup>14</sup> Youth who answered with any other response option to these 3 questions were considered susceptible. Data analyzed from the 1989 and the 1993 Teenage Attitudes and Practices Survey revealed that this susceptibility measure predicted almost twice the prevalence of smoking experimentation compared with nonsusceptible youth (66.5% vs 35.6%) at 4 years, as well as increased odds of experimentation with each subsequent level of

susceptibility.<sup>14</sup> These susceptibility items<sup>13</sup> were identified >25 years ago in a sample of 1789 California adolescents and validated in 4500 US adolescents.<sup>14</sup> Since 1992, smoking susceptibility has been used in the National Youth Tobacco Survey and other surveys of adolescents.<sup>15</sup> The susceptibility measure has been associated with smoking above and beyond significant factors that contribute to the onset of smoking among youth, such as exposure to other smokers, receptivity to tobacco marketing, and parental socioeconomic status.<sup>2</sup> To date, the predictive validity of the susceptibility measure has not been reassessed in a larger, nationally representative cohort of diverse youth.<sup>16-18</sup>

More than 20 years ago, the Master Settlement Agreement prohibited tobacco companies from directly and indirectly targeting youth through media.<sup>19</sup> Although advertising of tobacco products in media has been banned, the Master Settlement Agreement failed to include magazine advertising, which in turn continues to be used for tobacco advertising.<sup>19-21</sup> However, the landscape of tobacco-related marketing activity among youth has focused on the Internet, exposing youth to tobacco products through brand-specific Web sites, social media, and brand ambassadors.<sup>2,22-24</sup> Marketing efforts by tobacco companies have influenced cigarette use among youth before, and even after, such efforts were banned under law.<sup>2,22</sup> However, data on the role of this digital tobacco-related activity and smoking susceptibility predicting future smoking experimentation are limited.<sup>25,26</sup>

In studies of smoking susceptibility, researchers have generally examined associations with smoking behavior on the basis of cross-sectional studies,<sup>5,11,12,25,26</sup> but more evidence is needed on this strong association. Less is known about whether

adolescents are more or less susceptible based on their levels of response to the susceptibility measure and if that changes the association with smoking behavior in any way after accounting for tobacco-related marketing. In this study, we examined the effect of susceptibility to cigarette smoking behaviors in a cohort of diverse youth using 4 waves of longitudinal data from the Population Assessment of Tobacco Health (PATH) Study.<sup>27</sup> We hypothesized that levels of smoking susceptibility among never smokers would predict experimentation with cigarettes and current and established smoking at 4 years after adjusting for factors known to be associated with smoking behavior, including tobacco-related marketing and media exposure and electronic cigarette use.

## METHODS

### Data Source and Sampling

Public-use data came from 4 waves (2013–2018) of the nationally representative PATH Study, a longitudinal cohort study on tobacco use behavior, attitudes and beliefs, and tobacco-related health outcomes.<sup>28</sup> The study used a 4-stage stratified area probability sample design and oversampled young adults, tobacco users, and Black individuals. Details on the design and methods, interview procedures, questionnaires, sampling, weighting and adjustments for nonresponse, and information on accessing the data of the PATH Study were reported elsewhere<sup>27</sup> and are available online (<https://doi.org/10.3886/Series606>).

Youth never smokers aged 12 to 17 years at wave 1 who completed wave 4 were included in this analysis ( $n = 8899$ ). After receiving parental consent, data were collected in person through audio computer-assisted self-interviewing or computer-assisted personal interviewing, in which questions were

in either English or Spanish.<sup>27</sup> Institutional review board review was not required for this analysis of deidentified data (National Institutes of Health policy and the Code of Federal Regulations, title 45, part 46).

### Smoking Status

At wave 1, never smokers who responded no to “have you ever smoked a cigarette, even 1 or 2 puffs?” comprised the analytic sample of this study. At wave 4, experimental smokers self-reported as ever trying a cigarette (even 1 or 2 puffs), current smokers as having smoked cigarettes in the past 30 days, and established smokers as having smoked  $\geq 100$  cigarettes in their lifetime. Current and established smokers were included as experimenters. Electronic cigarette use was assessed as ever or in the past 12 months at each wave.

### Smoking Susceptibility

Susceptibility to cigarettes was assessed at wave 1 by the following 4 items: (1) Have you ever been curious about smoking a cigarette?<sup>13</sup>; (2) do you think you will smoke a cigarette in the next year?; (3) do you think that you will try a cigarette soon?; and (4) if one of your best friends were to offer you a cigarette, would you smoke it?<sup>14</sup> The response options were “very curious,” “somewhat curious,” “a little curious,” and “not at all curious” for item 1 and “definitely yes,” “probably yes,” “probably not,” and “definitely not” for items 2 to 4. Those who responded definitely not or not at all curious to all 4 questions were nonsusceptible (level 0), 3 questions were level 1 susceptible, 2 questions were level 2 susceptible, and 1 question or none were level 3 or 4 susceptible.

### Tobacco-Related Media and Marketing

Tobacco-related media was assessed by two dichotomous items: (1) seeing content posted about tobacco products on social media at wave 1 and (2) ever using a tobacco-related

app on a tablet computer or smartphone at wave 2 or 3. Tobacco-related marketing was consistently assessed at wave 1 (with supplemental assessments at wave 2) by 4 dichotomous items: (1) seeing a tobacco sweepstakes ad in the past 6 months or past 30 days; (2) ever using a smartphone to scan a quick response (QR) code for a tobacco product or to enter a sweepstakes or drawing from a tobacco company; (3) ever receiving a discount coupon for any tobacco product or any other information from a tobacco company in the past 6 months; and (4) ever receiving a free sample of a tobacco product in the past 6 months. In addition, engaging in online activity was assessed by ever signing up for e-mail alerts, reading articles, or watching videos online about tobacco in the past 6 or 12 months.

A derived variable was created for the number of times a participant saw movies containing tobacco use by assessing the frequency (never, once, or  $\geq 2$  times) of seeing 5 randomly selected films from 50 that were previously analyzed.

### Demographic and Smoking-Related Characteristics

Data on age, sex, parental education, household income, school performance reported by the parent, and exposure to other smokers (family only, best friends only, family and best friends, and none) were collected. Race and/or ethnicity were determined by self-report, and access to specific categorizations of non-Latino/a white (hence white), non-Latino/a Black (hence Black), and Latino/a was available. A derived variable was created for exposure to other smokers by using two items: (1) does anyone who lives with you now use tobacco, and (2) how many of your best friends smoke cigarettes? Because of the unavailability of disaggregated data in the public-use data set, all remaining racial and

ethnic groups were categorized as other.

### Data Analyses

The complex survey design was taken into account to calculate SEs. We used multivariable logistic regression to evaluate if smoking susceptibility levels at wave 1, exposure to tobacco-related media and marketing activities, and electronic cigarette use predicted experimental, current, or established smoking at wave 4. Models were adjusted for demographic and smoking-related characteristics. All analyses used appropriate sample weights and were conducted by using SAS version 9.4 (SAS Institute, Inc, Cary, NC).<sup>29</sup>

### RESULTS

Of 13 651 youth participants at wave 1, 8899 (65.2%) were never smokers and completed wave 4 (Table 1). Most never smokers (67.2%) were classified as nonsusceptible; the majority (54.9%) were between the ages of 12 and 14 years, almost half were girls (49.1%), and 46% were those who identified as Black, Latino/a, and other (Table 1).

At wave 4, 67.0% of never smokers reported no exposure to other smokers, and 18.4% had exposure from family only (Table 1). Ever use of electronic cigarettes increased from 4.3% of youth at wave 1 to 16.1% by wave 4. Tobacco-related media and marketing exposures included ever seeing content posted about tobacco products on social media (51.3%); ever seeing a tobacco sweepstakes ad (35.0%); ever receiving coupons or other information from a tobacco company (19.9%); and ever signing up for e-mail alerts, reading articles, or watching a video online about tobacco products (17.5%).

### Smoking Behavior at Wave 4

By wave 4, 16.4% of never smokers became experimental smokers, 7.6% were current smokers, and 1.8%

**TABLE 1** Baseline Demographic Factors, Smoking-Related Characteristics, and Tobacco-Related Media and Marketing Among Never Smokers: PATH Study, 2013 (*N* = 8899)

Characteristics	Total, <i>N</i> = 8899	Nonsusceptible, <sup>a,b</sup> <i>n</i> = 5976
	Frequency (%)	Frequency (%)
Demographic factors at wave 1		
Age, y		
12–14	5048 (54.9)	3563 (57.9)
15–17	3850 (45.1)	2413 (42.1)
Sex		
Female	4371 (49.1)	2916 (48.9)
Male	4506 (50.9)	3045 (51.1)
Race and/or ethnicity		
Black	1260 (14.0)	837 (13.7)
Latino/a	2606 (22.4)	1672 (21.3)
White	4062 (54.0)	2810 (55.3)
Other <sup>c</sup>	794 (9.6)	530 (9.7)
Parental education		
Less than high school	1821 (17.1)	1212 (17.0)
High school or equivalent	1574 (16.8)	1080 (17.4)
Some college or associate's degree	2711 (30.5)	1813 (30.4)
Bachelor's degree or above	2734 (35.5)	1833 (35.3)
Household income		
≥\$50 000	4075 (52.7)	2792 (53.6)
<\$50 000	4374 (47.3)	2896 (46.4)
School performance <sup>d</sup>		
Much better than average	5606 (65.6)	3884 (67.5)
Better than average	2308 (25.1)	1486 (23.8)
Average and below	909 (9.4)	557 (8.7)
Smoking-related characteristics at wave 4		
Exposure to other smokers		
None	5742 (67.0)	3991 (69.3)
Family only	1645 (18.4)	1036 (17.2)
Best friend only	889 (9.9)	561 (9.3)
Both family and best friends	430 (4.7)	261 (4.3)
Tobacco-related media and marketing at any wave		
Ever seen content about tobacco products on social media (wave 1 or 2)	4147 (51.3)	2515 (47.1)
Ever used a tobacco-related app on tablet computer or smartphone (wave 2 or 3)	447 (5.1)	260 (4.4)
Ever seen a tobacco sweepstakes ad (wave 1 or 2)	3180 (35.0)	1996 (32.8)
Ever used a smart phone to scan a QR code for a tobacco product or to enter a sweepstakes (wave 1)	200 (3.3)	103 (2.7)
Ever signed up for e-mail alerts, read articles, or watched a video online about tobacco products (wave 1 or 2)	1491 (17.5)	831 (14.5)
Ever received a coupon or other information from a tobacco company (wave 1–4)	1751 (19.9)	1012 (17.1)
Ever received a free sample of a tobacco product (wave 1–4)	303 (3.4)	159 (2.6)
No. times seen movies with tobacco use (wave 1)		
Never	3300 (37.2)	2391 (40.1)
Once	1654 (19.0)	1138 (19.6)
≥2 times	3945 (43.8)	2447 (40.3)

Percentages are weighted.

<sup>a</sup> Susceptibility items include (1) have you ever been curious about smoking a cigarette?; (2) do you think you will try a cigarette soon?; (3) if your best friend were to offer, would you smoke it?; and (4) do you think you will smoke a cigarette in the next year?

<sup>b</sup> Susceptibility levels: 0 = response of definitely not to all 4 susceptibility items; 1, 2, 3, or 4 = response of probably not, probably yes, or definitely yes to ≥1 susceptibility item.

<sup>c</sup> Because of unavailability of disaggregated data in public-use data set, the categorization other included youth who identified as Pacific Islander, American Indian, and Asian American.

<sup>d</sup> Much better than average = mostly A's or A's and B's; better than average = mostly B's or B's and C's; average and below = mostly C's, C's and D's, mostly D's, D's and F's, or mostly F's.

were established smokers, although 67.2% remained never smokers (Table 2). Response frequencies to the 4 susceptibility questions at wave 1 are shown in Table 2. Of 1297 youth who reported that they might smoke in the next year, 40.3% became experimental, 20.0% became current, and 5.4% became established smokers at wave 4. The other 3 questions were associated with future smoking behavior at wave 4, with endorsements of items “curiosity to smoking cigarettes,” “smoke in next year,” and “best friend offers” being 29.9%, 40.3%, and 36.8% of experimental smokers; 14.2%, 20.0%, and 17.0% of current smokers; and 3.6%, 5.4%, and 4.7% of established smokers, respectively. Additionally, the prevalence of experimental, current, or established smoking at wave 4 was proportional with levels of susceptibility at wave 1 because larger proportions of youth reported experimental, current, or established smoking with increasing susceptibility levels (Table 2).

### Levels of Susceptibility Predicting Future Smoking Status

Adjusted for demographic factors and smoking-related characteristics, susceptibility predicted smoking outcomes at 4 years. Compared with nonsusceptible adolescents, those who endorsed one susceptibility item at wave 1 were more likely to be experimental (adjusted odds ratio [aOR] = 2.0; 95% confidence interval [CI] = 1.7–2.3) and current (aOR = 1.7; 95% CI = 1.3–2.1) smokers at wave 4 (Table 3). Youth with level 2 susceptibility at wave 1 were more likely to be experimental smokers (aOR = 3.8; 95% CI = 3.1–4.7), and youth with susceptibility levels 3 or 4 were more likely to be experimental smokers (aOR = 6.9; 95% CI = 5.7–8.4) at wave 4 (Table 3). Each individual susceptibility item significantly predicted experimental smoking at wave 4, and “think you will try in the next year” was significantly associated with current



**TABLE 2** Susceptibility Levels at Wave 1 by Smoking Status at Wave 4: PATH Study, 2013–2018 (N = 8899)

Characteristics	Wave 1, <i>n</i>	Wave 4, <i>n</i> (%)						
	Never, <sup>a</sup> <i>n</i> = 8899 (100%)	Experimental, <sup>a</sup> <i>n</i> = 1423 (16.4%)		Current, <sup>a</sup> <i>n</i> = 648 (7.6%)		Established, <sup>a</sup> <i>n</i> = 151 (1.8%)		Never, <sup>a</sup> <i>n</i> = 5976 (67.2%)
	Yes	Yes	No	Yes	No	Yes	No	Yes
Susceptibility items								
Curiosity	2194	638 (29.9)	1556 (70.1)	294 (14.2)	1900 (85.8)	70 (3.6)	2124 (96.4)	1556 (70.1)
Smoke in next year	1297	500 (40.3)	797 (59.7)	237 (20.0)	1060 (80.0)	64 (5.4)	1233 (94.6)	797 (59.7)
Try a cigarette soon	55	36 (67.8)	19 (32.2)	19 (35.6)	36 (64.4)	4 (9.4)	51 (90.6)	19 (32.2)
Best friend offers	1425	505 (36.8)	920 (63.2)	223 (17.0)	1202 (83.0)	60 (4.7)	1365 (95.3)	920 (63.2)
Susceptibility level <sup>b</sup>								
Level 0	5976	603 (10.2)	5373 (89.8)	278 (4.7)	5698 (95.3)	62 (1.1)	5914 (98.9)	5373 (89.8)
Level 1	1568	294 (19.3)	1274 (80.7)	123 (8.3)	1445 (91.7)	22 (1.5)	1546 (98.5)	1274 (80.7)
Level 2	703	223 (32.9)	480 (67.1)	106 (16.1)	597 (83.9)	28 (4.5)	675 (95.5)	480 (67.1)
Level 3	607	273 (46.9)	334 (53.1)	126 (22.6)	481 (77.4)	36 (6.5)	571 (93.5)	334 (53.1)
Level 4	44	30 (71.4)	14 (28.6)	15 (37.8)	29 (62.2)	3 (10.3)	41 (89.7)	14 (28.6)
Level 3 + 4	651	303 (48.5)	348 (51.5)	141 (23.6)	510 (76.4)	39 (6.7)	612 (93.3)	348 (51.5)

Percentages are weighted. Numbers add horizontally (number of people susceptible at wave 1 = numbers of experimental, current, established, and never smokers at wave 4).

<sup>a</sup> Never = Have not tried or smoked a cigarette; experimental = ever tried or smoked a cigarette, even 1 or 2 puffs; current = smoked a cigarette in the past 30 d; and established = smoked  $\geq 100$  cigarettes in lifetime. Smoking statuses are nonmutually exclusive.

<sup>b</sup> Susceptibility levels: 0 = response of definitely not to all 4 susceptibility items; 1, 2, 3 or 4 = response of probably not, probably yes, or definitely yes to  $\geq 1$  susceptibility item.

and established smoking as well (Supplemental Table 6).

Compared with white youth, Black youth were half as likely to be experimental (aOR = 0.5; 95% CI = 0.4–0.6) or current (aOR = 0.5; 95% CI = 0.4–0.7) smokers at wave 4 (Table 3). Latino/a youth were also significantly less likely to be experimental (aOR = 0.8; 95% CI = 0.7–1.0) or current (aOR = 0.7; 95% CI = 0.5–0.9) smokers at wave 4. Boys were significantly more likely than girls to report smoking behaviors. Parental report of school performance had a modest effect on experimental smoking, and the risk of smoking behaviors increased when participants reported exposure to smoking by family and best friends (Table 3).

### Tobacco-Related Media and Marketing in Predicting Youth Smoking

Adjusted for tobacco-related media and marketing, youth who endorsed 3 or 4 susceptibility items at wave 1 were 6.0 times more likely to be experimental smokers (95% CI = 4.8–7.4), 4.2 times more likely to be current smokers (95% CI = 3.2–5.4), and 4.4 times more likely to be established smokers (95% CI =

2.4–7.9) at wave 4 (Table 4). Level 1 susceptibility at wave 1 also predicted experimental and current smoking, but the risk of established smoking was attenuated when adjusting for the media and marketing variables.

Tobacco-related media and marketing responses were significantly associated with smoking outcomes in the models after adjusting for susceptibility level. Youth who reported having ever seen content posted about tobacco products on social media (aOR = 1.2; 95% CI = 1.0–1.4), having ever used a tobacco-related app on a tablet computer or smartphone (aOR = 1.6; 95% CI = 1.1–2.2), recently receiving a discount coupon or other information from a tobacco company (aOR = 1.3; 95% CI = 1.1–1.5), or recently receiving a free sample of a tobacco product (aOR = 2.6; 95% CI = 1.9–3.4) were more likely to be experimental smokers at wave 4 (Table 4). Similar effects on current smoking were found for having used a tobacco-related app, having received a coupon or other information, and receiving a free sample of a tobacco product. Engaging in online activity was only associated with established smoking (aOR = 1.6; 95% CI = 1.0–2.5).

### Level of Susceptibility With Electronic Cigarette Use Predicting Future Smoking Status

Adjusting for demographic factors and smoking-related characteristics, susceptibility predicted smoking outcomes at 4 years after including electronic cigarette use at any wave. Levels of susceptibility predicted experimental (level 1: aOR = 1.5; 95% CI = 1.3–1.8; level 2: aOR = 2.3; 95% CI = 1.9–3.0; and level 3 or 4: aOR = 3.7; 95% CI = 2.9–4.6) and current (level 2: aOR = 1.9; 95% CI = 1.4–2.6; level 3 or 4: aOR = 2.5; 95% CI = 1.9–3.3) smoking (Table 5), although these were attenuated compared with those in Table 3. Use of electronic cigarettes at any wave was associated with an increased risk of experimental cigarette use (aOR = 7.7; 95% CI = 6.6–9.1) among youth. When electronic cigarette use at any wave was included in the model, only “ever received a free sample of a tobacco product” remained significant for experimental smoking at wave 4 (Supplemental Table 7).

### DISCUSSION

Despite changes in the tobacco product media landscape over the past 30 years, we replicated previous

**TABLE 3** Multivariable Logistic Regression Model of Smoking Status at Wave 4 Among Never Smokers at Wave 1: PATH Study, 2013 (Wave 1) to 2018 (Wave 4) (N = 8899)

	Experimental Smokers <sup>a</sup>	Current Smokers <sup>a</sup>	Established Smokers <sup>a</sup>
	aOR <sup>b</sup> (95% CI)	aOR <sup>b</sup> (95% CI)	aOR <sup>b</sup> (95% CI)
Susceptibility level at wave 1 (ref: level 0)			
1	2.0 (1.7–2.3) <sup>c</sup>	1.7 (1.3–2.1) <sup>c</sup>	1.2 (0.6–2.2)
2	3.8 (3.1–4.7) <sup>c</sup>	3.2 (2.5–4.2) <sup>c</sup>	3.3 (2.0–5.6) <sup>c</sup>
3 + 4	6.9 (5.7–8.4) <sup>c</sup>	4.9 (3.8–6.2) <sup>c</sup>	5.0 (2.8–9.0) <sup>c</sup>
Characteristics at wave 1			
Age, y (ref: 12–14 )			
15–17	3.3 (2.8–3.9) <sup>c</sup>	4.20 (3.3–5.4) <sup>c</sup>	4.7 (2.7–8.2) <sup>c</sup>
Sex (ref: female)			
Male	1.3 (1.1–1.5) <sup>c</sup>	1.38 (1.1–1.7) <sup>c</sup>	1.7 (1.2–2.4) <sup>c</sup>
Race and/or ethnicity (ref: white)			
Black	0.5 (0.4–0.6) <sup>c</sup>	0.5 (0.4–0.7) <sup>c</sup>	0.2 (0.04–0.6) <sup>c</sup>
Latino/a	0.8 (0.7–1.0) <sup>c</sup>	0.7 (0.5–0.9) <sup>c</sup>	0.6 (0.3–1.0)
School performance <sup>d</sup> (ref: much better than average)			
Better than average	1.4 (1.2–1.6) <sup>c</sup>	1.4 (1.1–1.7) <sup>c</sup>	1.2 (0.8–1.8)
Average and below	1.5 (1.2–1.9) <sup>c</sup>	1.5 (1.0–2.1) <sup>c</sup>	1.7 (1.0–2.8)
Smoking-related characteristics at wave 4			
Exposure to other smokers (ref: no exposure)			
Family only	1.7 (1.4–2.1) <sup>c</sup>	2.5 (2.0–3.1) <sup>c</sup>	2.8 (1.9–4.3) <sup>c</sup>
Best friend only	3.2 (2.4–4.3) <sup>c</sup>	4.1 (2.9–5.8) <sup>c</sup>	2.6 (1.1–5.8) <sup>c</sup>
Both family and best friends	7.8 (5.7–10.7) <sup>c</sup>	10.2 (6.7–15.4) <sup>c</sup>	10.9 (5.8–20.7) <sup>c</sup>

ref, reference group.

<sup>a</sup> Experimental = ever tried or smoked a cigarette, even 1 or 2 puffs; current = smoked a cigarette in the past 30 d; and established = smoked  $\geq 100$  cigarettes in lifetime.

<sup>b</sup> Model also included parental education and household income.

<sup>c</sup> Statistically significant at an  $\alpha < 0.05$  level.

<sup>d</sup> Much better than average = mostly A's or A's and B's; better than average = mostly B's or B's and C's; and average and below = mostly C's, C's and D's, mostly D's, D's and F's, or mostly F's.

findings<sup>13, 14</sup> that a measure of susceptibility to cigarette use in a cohort of diverse youth predicts experimental smoking 4 years later. These results suggest a dose-response relationship between susceptibility and subsequent smoking behavior even after accounting for measures of tobacco-related media and marketing exposure. Susceptibility was consistently a robust predictor of smoking initiation even as tobacco-related media and marketing variables also influenced the onset of smoking. This study highlights smoking susceptibility as a risk factor of future smoking in the setting of tobacco industry efforts, which influence smoking onset among youth.

The finding that smoking susceptibility among youth who have never smoked, even a puff, is a predictor of future smoking initiation is not novel but has remained significant over decades of

change in tobacco marketing.<sup>2,3,30</sup> In our study, we found that affirmative responses to at least 1 smoking susceptibility question led to an increased risk of experimental smoking, and higher levels of susceptibility substantially increased the risk of experimental, current, and established smoking by threefold to sixfold. In the study by Pierce et al<sup>14</sup> from 25 years ago, the proportion of youth who experimented (40%) or were established (8%) cigarette smokers at 4 years of follow-up was much higher than that among the PATH Study participants (16.4% and 1.8%, respectively). This difference probably reflects the success of combustible cigarette use prevention and secular trends over the past several decades among youth, but the lack of decrease in susceptibility raises concerns.<sup>2,30</sup> However, this success story of tobacco control efforts warrants caution. The introduction of new tobacco products, such as electronic cigarettes, has

shifted the types of tobacco products used by youth and may well function as a pathway to experimental smoking.<sup>23,30–33</sup> Furthermore, universal access to the Internet and the presence of the tobacco industry online did not exist at the time of the earlier study.<sup>14</sup>

Behavioral issues and preventive services usually dominate clinical visits of healthy adolescents. Our data suggest that including these 4 simple susceptibility questions in routine clinical visits should be considered in addition to tobacco use behavior questions. Incorporating the susceptibility measure in young adolescents' annual visits would potentially alert the clinician to at-risk youth and help prevent future smoking. Awareness of susceptibility may lead clinicians to focus on potential prevention interventions, such as assisting a smoking parent to quit.<sup>2–4,34–36</sup>

Overall, boys were more likely to experiment than girls, whereas Black

**TABLE 4** Multivariable Logistic Regression Model Estimates of Smoking Status at Wave 4 Among Never Smokers at Wave 1, Including Tobacco-Related Media and Marketing at Any Wave: PATH Study, 2013 (Wave 1) to 2018 (Wave 4) (*N* = 8899)

	Experimental Smokers <sup>a</sup>	Current Smokers <sup>a</sup>	Established Smokers <sup>a</sup>
	aOR <sup>b</sup> (95% CI)	aOR <sup>b</sup> (95% CI)	aOR <sup>b</sup> (95% CI)
Susceptibility level at wave 1 (ref: level 0)			
1	1.9 (1.6–2.2) <sup>c</sup>	1.6 (1.3–2.0) <sup>c</sup>	1.1 (0.6–2.1)
2	3.5 (2.8–4.3) <sup>c</sup>	2.9 (2.2–3.9) <sup>c</sup>	2.7 (1.5–4.8) <sup>c</sup>
3 + 4	6.0 (4.8–7.4) <sup>c</sup>	4.2 (3.2–5.4) <sup>c</sup>	4.4 (2.4–7.9) <sup>c</sup>
Characteristics at wave 1			
Age, y (ref: 12–14)			
15–17	3.0 (2.5–3.6) <sup>c</sup>	3.8 (3.0–4.9) <sup>c</sup>	4.2 (2.4–7.1) <sup>c</sup>
Sex (ref: female)			
Male	1.3 (1.1–1.46) <sup>c</sup>	1.4 (1.1–1.7) <sup>c</sup>	1.7 (1.2–2.6) <sup>c</sup>
Race and/or ethnicity (ref: white)			
Black	0.5 (0.3–0.6) <sup>c</sup>	0.5 (0.3–0.6) <sup>c</sup>	0.1 (0.0–0.5) <sup>c</sup>
Latino/a	0.8 (0.7–1.0) <sup>c</sup>	0.7 (0.6–0.9) <sup>c</sup>	0.6 (0.3–1.0)
School performance <sup>d</sup> (ref: much better than average)			
Better than average	1.4 (1.2–1.6) <sup>c</sup>	1.3 (1.1–1.7) <sup>c</sup>	1.0 (0.6–1.6)
Average and below	1.5 (1.2–1.7) <sup>c</sup>	1.37 (1.0–2.0)	1.6 (0.9–2.7)
Smoking-related characteristics at wave 4			
Exposure to other smokers (ref: no exposure)			
Family only	1.6 (1.3–2.0) <sup>c</sup>	2.4 (1.9–3.1) <sup>c</sup>	2.8 (1.8–4.4) <sup>c</sup>
Best friend only	3.0 (2.2–4.0) <sup>c</sup>	3.8 (2.6–5.4) <sup>c</sup>	2.1 (0.9–4.9)
Both family and best friends	7.0 (5.0–9.8) <sup>c</sup>	9.0 (5.8–14.1) <sup>c</sup>	9.3 (4.7–18.4) <sup>c</sup>
Tobacco-related media and marketing at any wave			
Ever seen content about tobacco products on social media <sup>e</sup> (ref: no)	1.2 (1.0–1.4) <sup>c</sup>	1.1 (0.9–1.3)	1.1 (0.7–1.6)
Ever used a tobacco-related app on a tablet computer or smartphone <sup>f</sup> (ref: no)	1.6 (1.1–2.2) <sup>c</sup>	1.7 (1.0–2.7) <sup>c</sup>	1.7 (0.7–3.9)
Ever seen a tobacco sweepstakes ad <sup>e</sup> (ref: no)	0.9 (0.8–1.1)	0.9 (0.7–1.1)	0.9 (0.6–1.4)
Ever used a smartphone to scan a QR code for a tobacco product or to enter a sweepstakes <sup>g</sup> (ref: no)	0.9 (0.6–1.4)	0.8 (0.4–1.4)	1.4 (0.5–4.1)
Ever signed up for e-mail alerts, read articles, or watched a video online about tobacco products <sup>e</sup> (ref: no)	1.0 (0.9–1.2)	1.0 (0.8–1.4)	1.6 (1.0–2.5) <sup>c</sup>
Ever received a coupon or other information from a tobacco company <sup>h</sup> (ref: no)	1.3 (1.1–1.5) <sup>c</sup>	1.4 (1.1–1.8) <sup>c</sup>	1.3 (0.8–2.0)
Ever received a free sample of a tobacco product <sup>h</sup> (ref: no)	2.6 (1.9–3.4) <sup>c</sup>	2.0 (1.4–2.8) <sup>c</sup>	2.1 (1.1–4.03) <sup>c</sup>
No. times seen movies with tobacco use <sup>g</sup> (ref: never)			
Once	0.9 (0.8–1.1)	0.9 (0.7–1.3)	0.7 (0.3–1.4)
≥2 times	1.1 (1.0–1.3)	1.2 (1.0–1.4)	0.9 (0.6–1.4)

ref, reference group.

<sup>a</sup> Experimental = ever tried or smoked a cigarette, even 1 or 2 puffs; current = smoked a cigarette in the past 30 d; and established = smoked ≥100 cigarettes in lifetime.

<sup>b</sup> Model also included household income, parental education, and how often you visit social media accounts.

<sup>c</sup> Statistically significant at an  $\alpha < 0.05$  level.

<sup>d</sup> Much better than average = mostly A's or A's and B's; better than average = mostly B's or B's and C's; and average and below = mostly C's, C's and D's, mostly D's, D's and F's, or mostly F's.

<sup>e</sup> Asked at wave 1 or 2.

<sup>f</sup> Asked at wave 2 or 3.

<sup>g</sup> Asked at wave 1.

<sup>h</sup> Asked at wave 1, 2, 3, or 4.

and Latino/a youth were less likely to experiment with smoking. This corroborates research that suggests Black youth are less susceptible than white youth to experimental smoking at 4 years of follow-up.<sup>14</sup> In cross-sectional studies, researchers have found Latino/a youth never smokers to be just as susceptible, if not more susceptible, to future smoking compared with white youth.<sup>11,12,16</sup>

Importantly, the incidence of experimentation was highest in respondents exposed to smoking by both their family and their best friends, which reemphasizes the significance of social influences on smoking initiation among youth. Furthermore, electronic cigarette use at any wave was found to be predictive of experimentation and current use. These findings further

validate previous research that indicates electronic cigarette use is associated with cigarette initiation and current cigarette use among youth never smokers at follow-up.<sup>7–10</sup>

Although level of susceptibility was a robust predictor of future smoking among youth never smokers, the limited contribution of exposure to tobacco-related media and marketing factors is of note. In previous studies,

**TABLE 5** Multivariable Logistic Regression Model of Smoking Status at Wave 4 Among Never Smokers at Wave 1, Including Electronic Cigarette Use at Any Wave: PATH Study, 2013 (Wave 1) to 2018 (Wave 4) (*N* = 8899)

	Experimental Smokers <sup>a</sup>	Current Smokers <sup>a</sup>	Established Smokers <sup>a</sup>
	aOR <sup>b</sup> (95% CI)	aOR <sup>b</sup> (95% CI)	aOR <sup>b</sup> (95% CI)
Susceptibility level at wave 1 (ref: level 0)			
1	1.5 (1.3–1.8) <sup>c</sup>	1.3 (1.0–1.7)	0.9 (0.5–1.7)
2	2.3 (1.9–3.0) <sup>c</sup>	1.9 (1.4–2.6) <sup>c</sup>	2.0 (1.2–3.4) <sup>c</sup>
3 + 4	3.7 (2.9–4.6) <sup>c</sup>	2.5 (1.9–3.3) <sup>c</sup>	2.7 (1.5–4.8) <sup>c</sup>
Characteristics at wave 1			
Age, y (ref: 12–14 y)			
15–17	2.7 (2.2–3.3) <sup>c</sup>	3.3 (2.6–4.4) <sup>c</sup>	3.8 (2.1–6.7) <sup>c</sup>
Sex (ref: female)			
Male	1.2 (1.0–1.4) <sup>c</sup>	1.4 (1.1–1.7) <sup>c</sup>	1.7 (1.2–2.4) <sup>c</sup>
Race and/or ethnicity (ref: white)			
Black	0.6 (0.4–0.7) <sup>c</sup>	0.6 (0.4–0.8) <sup>c</sup>	0.2 (0.1–0.6) <sup>c</sup>
Latino/a	0.8 (0.7–1.0)	0.7 (0.5–0.9) <sup>c</sup>	0.6 (0.4–1.0)
School performance <sup>d</sup> (ref: much better than average)			
Better than average	1.3 (1.1–1.5) <sup>c</sup>	1.3 (1.0–1.6) <sup>c</sup>	1.1 (0.7–1.6)
Average and below	1.3 (1.0–1.6)	1.2 (0.9–1.7)	1.5 (0.9–2.5)
Smoking-related characteristics at wave 4			
Exposure to other smokers (ref: no exposure)			
Family only	1.5 (1.2–1.8) <sup>c</sup>	2.2 (1.7–2.8) <sup>c</sup>	2.5 (1.6–3.8) <sup>c</sup>
Best friend only	2.8 (2.0–3.8) <sup>c</sup>	3.5 (2.4–5.13) <sup>c</sup>	2.2 (0.9–5.1)
Both family and best friends	6.2 (4.4–8.6) <sup>c</sup>	7.5 (4.8–11.7) <sup>c</sup>	7.7 (4.1–14.6) <sup>c</sup>
E-cigarette use at any wave (ref: no)	7.7 (6.6–9.1) <sup>c</sup>	7.5 (5.8–9.8) <sup>c</sup>	6.3 (3.7–10.7) <sup>c</sup>

ref, reference group.

<sup>a</sup> Experimental = ever tried or smoked a cigarette, even 1 or 2 puffs; current = smoked a cigarette in the past 30 d; and established = smoked  $\geq 100$  cigarettes in lifetime.

<sup>b</sup> Model also included parental education and household income.

<sup>c</sup> Statistically significant at an  $\alpha < 0.05$  level.

<sup>d</sup> Much better than average = mostly A's or A's and B's; better than average = mostly B's or B's and C's; and average and below = mostly C's, C's and D's, mostly D's, D's and F's, or mostly F's.

researchers have found that online tobacco advertisement receptiveness is associated with youth never users becoming susceptible and progressing to the uptake of smoking.<sup>16,22,23,32,33,37,38</sup>

Furthermore, the overwhelming presence of social media and virtual life among US youth would lead one to consider these exposures to be the dominant predictors of future smoking. Although our data were consistent and build on previous cross-sectional research<sup>16,39</sup> that predictors of media exposure and marketing led to experimentation of cigarette smoking at 4 years, susceptibility remained a strong predictor of smoking initiation among youth. It is plausible that youth who are more susceptible become more

receptive to tobacco industry outreach, and one study found that receiving tobacco coupons was associated with increased susceptibility for trying a cigarette soon and trying a cigarette in the next year.<sup>33</sup> Furthermore, receiving coupons or samples predicted future experimentation and current use. One explanation could be that although most tobacco companies use strict age verification procedures to prevent youth from viewing tobacco advertising and purchasing on their company Web sites,<sup>22,23</sup> there are no regulations on other online activities by tobacco companies, such as on social media platforms or through Internet influencers who promote specific products using their online persona.<sup>2</sup>

## Limitations

We were not able to disaggregate the racial and ethnic category other or account for the national backgrounds of Latino/a participants. Tobacco exposure, media, and marketing variables were not available at all 4 waves of PATH Study, which prevented us from analyzing all variables longitudinally. Smoking status was self-reported. However, population-based surveys have not been associated with biased prevalence estimates.<sup>40,41</sup> In this study, we focused on the role of susceptibility to smoking and did not incorporate behavioral factors related to electronic cigarette use in determining smoking behavior.

## CONCLUSIONS

Advancing our understanding of the importance of smoking susceptibility in the context of a changed media landscape that leads to future smoking is critical to develop and expand tobacco use prevention programs and policies designed for youth. The 4-item susceptibility measure is a robust predictor of future cigarette use among adolescent never smokers. Recent exposure to online industry marketing activity was predictive of experimental smoking, and additional research is needed to analyze the role of receptivity to tobacco-related online activity. In future work, researchers should also consider the use of illicit drugs, mental health symptoms, and the use of other tobacco products as a predictor of initiation of combustible cigarette use.

## ABBREVIATIONS

aOR: adjusted odds ratio  
CI: confidence interval  
PATH: Population Assessment of Tobacco and Health  
QR: quick response



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